



LIVING MARINE RESOURCES PROJECT 33

TTS in Harbor Seals Due to Fatiguing Sound of Several Frequencies

NEED

The Navy needs more data to improve the Navy's acoustic and explosive impact assessments for marine species. Priority interest is in species for which no, or insufficient, data are available. Areas of focus include audiograms (hearing sensitivity) in marine species, data on temporary threshold shift (TTS) due to various frequencies, and effects on fish due to the detonation of explosive devices of various charge sizes, depths and distances to the subjects. The Navy needs improved hearing data in order to update risk threshold criteria, reduce the uncertainty of the current impact assessments and validate mitigation measures.

SOLUTION

This project focuses on TTS and hearing recovery in harbor seals for deriving auditory weighting functions for seals. Harbor seals are appropriate subjects for multiple reasons. They have a wide distribution in the northern hemisphere and sometimes overlap with areas used for U.S. Navy training and testing activities. With their acute underwater hearing, sounds from the training and testing activities are audible to harbor seals. In addition, while susceptibility to TTS has been shown to be frequency-dependent in bottlenose dolphins (*Tursiops truncatus*) and harbor porpoises (*Phocoena phocoena*), currently it is not clear how sounds of different frequencies may affect the hearing of harbor seals across their entire functional hearing range.



Female seal 01 hauled out (showing dry hair). During fatiguing sound distribution measurements (for the TTS study) in the pool, the animals are kept on land and thus their hair dries.

Ron Kastelein, SEAMARCO

To evaluate the frequency-dependence in seal hearing, the project goals are to:

1. Determine the susceptibility to TTS of harbor seals over their entire hearing range.
2. Determine TTS onset, relationship between sound exposure level (SEL, a unit which contains both the exposure level and the exposure duration) and TTS after the harbor seals have been exposed to sounds of various frequencies. Because all exposures in this study will be one hour, the reported SELs are 36 decibels higher than the reported sound pressure levels (SPL).

3. Determine which hearing frequency is most affected by each fatiguing sound frequency.
4. Determine the recovery rate of hearing after the fatiguing sound stops.
5. Based on the information derived for goals 1–3, construct equal-TTS curves (one of which will be the TTS onset curve).

Results from these tests on harbor seals will be used as the model for all true seals (Phocids).

METHODOLOGY

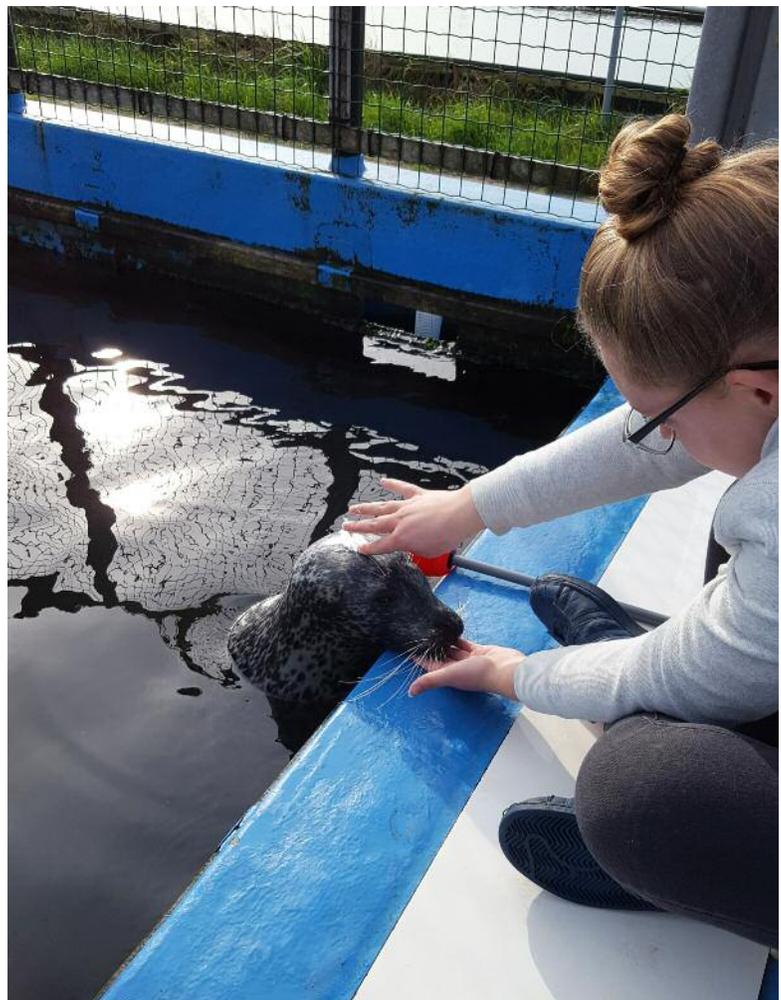
The project is employing two harbor seals that have been trained for research and have participated almost daily in psychophysical acoustic research for 14 years. During a hearing test, the trained harbor seals will wait at a listening station, at a specific distance from the underwater loudspeaker. When they hear a sound, they will leave the station and swim towards the trainer for a reward. Each TTS session will include a pre-exposure hearing test, exposure to a fatiguing sound of a particular frequency and several post-exposure hearing threshold measurements to determine the rate of recovery of hearing.

Nine fatiguing sounds are being tested: a continuous tone (6.5 kilohertz or kHz) and continuous 1/6-octave noise bands centered at 0.125, 0.250, 0.5, 1.0, 2.0, 16, 32 and 40 kHz. Control sessions are conducted for each hearing test frequency. Exposure duration will be one hour per session. Each fatiguing sound will be produced at five SPLs, of which three will result in approximately the following TTS levels: 6, 12 and 18 decibels. This approach provides insight into the relationship between TTS and SPL. Two or three hearing frequencies will be tested per fatiguing sound frequency (often the highest TTS occurs at a higher

frequency than the frequency of the fatiguing sound). Each of the three highest SPLs (and the controls) will be replicated multiple times.

SCHEDULE

Data collection is expected to be completed within approximately 26 months. A draft report will be prepared within two months after data collection has been completed. This project is expected to be completed by the end of 2020.



Trainer applying zinc ointment on the head of seal 02 to enable individual recognition of the two seals during the sound exposure, to calculate the distances between the seals and the sound source (for the exposure periods of the temporary hearing threshold shift (TTS) study).

Ron Kastelein, SEAMARCO

NAVY BENEFITS

Navy acoustic impact criteria use auditory weighting functions to predict the onset of TTS and PTS as functions of sound frequency. The data resulting from the proposed effort will be used to define the Navy Phase IV weighting function and TTS/PTS threshold values for the phocid (seals) group. The data will be directly applicable to all Navy environmental documents analyzing acoustic effects of tonal sounds (e.g., sonars) and broadband noise sources and could be used (via extrapolation) for criteria for impulse sources.

TRANSITION

The primary avenue for distributing project results will be several peer-reviewed journal articles that describe TTS as a function of exposure to sounds of various frequencies. In addition, conference presentations are planned in which preliminary results will be

presented. Results will be available to a range of recipients, including the Navy environmental community, producers and regulators of underwater sound (e.g., National Marine Fisheries Service, Bureau of Ocean Energy Management), and the general scientific community.

ABOUT THE PRINCIPAL INVESTIGATOR

Since 2002, Ron Kastelein, Ph.D. (University of Wageningen, The Netherlands) has been director and owner of SEAMARCO (Sea Mammal Research Company, Inc.) in The Netherlands. SEAMARCO specializes in applied acoustic research and energetic studies with marine fauna (mammals, fish, turtles and invertebrates).



About the LMR Program

The Living Marine Resources (LMR) program seeks to develop, demonstrate, and assess data and technology solutions to protect living marine resources by minimizing the environmental risks of Navy at-sea training and testing activities while preserving core Navy readiness capabilities. For more information, contact the LMR program manager at exwc_lmr_program@navy.mil or visit navysustainability.dodlive.mil/environment/lmr/.

